Journal of Behavioral Medicine, Vol. 23, No. 3, 2000

The Relative Efficacy of Three Cognitive-Behavioral Treatment Approaches to Temporomandibular Disorders

Kiran D. Mishra,[1] Robert J. Gatchel,[1,2] and Margaret A. Gardea[1]

Accepted for publication: December 20, 1999

The purpose of this study was to evaluate the relative efficacy of different biopsychosocial treatment conditions on patients with chronic temporomandibular disorder. Ninety-four patients with chronic temporomandibular disorder were assigned to either a biofeedback treatment group, a cognitive-behavioral skills training (CBST) treatment group, a combined (combination of biofeedback/CBST) treatment group, or a no-treatment control group. Pain scores were analyzed pretreatment and posttreatment to determine group and within-subjects treatment effects. Results demonstrated that, in terms of a self-reported pain score, all three treatment groups had significantly decreased pain scores from pretreatment to posttreatment, while the no-treatment group did not. Moreover, patients in the biofeedback group were the most significantly improved compared to the no-treatment group. Finally, participants in the three treatment groups displayed significant improvement in mood states.

KEY WORDS: temporomandibular disorder; biopsychosocial perspective; cognitive-behavioral skills training; biofeedback; RDC/TMD diagnosis.

INTRODUCTION

Temporomandibular disorders (TMD) can be defined as a heterogeneous collection of disorders that are marked by orofacial pain, masticatory dysfunction, or both. Dworkin and LeResche (1992) developed the Research

[1]Department of Psychiatry, Division of Psychology, The University of Texas Southwestern Medical Center at Dallas, 5323 Harry Hines Boulevard, Dallas, Texas 75235-9044.
[2]To whom correspondence should be addressed. Fax: 214-648-5297. e-mail: robert.gatchel@email.swmed.edu.

0892-7553/00/0600-0293$18.00/0

Diagnostic Criteria (RDC), a classification system that includes standardized criteria for the diagnosis of TMD. The RDC assesses patients on two axes. Clinical disorders are assessed on Axis I, which allows for a diagnosis of one muscle disorder (myofacial pain or myofacial pain with limited opening), a disc displacement diagnosis for each joint (disc displacement with reduction, disc displacement without reduction with limited opening, and disc displacement without reduction without limited opening), and up to two diagnoses of a joint condition (arthralgia, arthritis, or arthrosis). Within Axis II, individuals are assessed for pain-related disability and psychological factors. Axis II consists of three components: a graded chronic pain scale (GCPS), measures of depression, and number of nonspecific physical symptoms.

Most clinical researchers now view the RDC as an important improvement from previous diagnostic classification schemas, as it offers a dual-axis system, taking into account biological, psychological, and social factors. It is currently the most widely accepted method of diagnosing TMD. Indeed, the RDC embraces a biopsychosocial model which emphasizes the importance of a multimodal approach to treating pain conditions (Turk, 1997). According to this perspective, physical, cognitive, affective, and behavioral factors all interact and contribute to the experience of chronic pain. These factors are thought to be interdependent, with each factor impacting the others.

Traditionally, different treatments for TMD included interocclusal appliances, cognitive-behavioral techniques, nocturnal alarms, surgery, physical therapy, and occlusal equilibration. Of these treatments, however, cognitive-behavioral techniques may have long-term advantages over dental and pharmacological techniques in managing the pain related to TMD (Glaros and Glass, 1993). For example, Fernandez and Turk (1989) performed a meta-analysis of 51 research studies to determine the overall efficacy, substantive efficacy, and relative efficacy of cognitive coping strategies in influencing self-reported pain. Results showed 85% of the investigations had a positive outcome in increasing pain tolerance, increasing pain threshold or decreasing pain ratings compared to a no-treatment condition. Regarding substantive efficacy, cognitive coping strategies reduced pain significantly compared to no-treatment and placebo conditions. Finally, they examined the relative efficacy of various cognitive strategies on influencing pain. These strategies included external focus of attention, neutral imagery, pleasant imagery, dramatized coping, rhythmic cognitive activity, and pain acknowledging. Each of these strategies proved to significantly reduce pain, with imagery being the most effective, and strategies that involved repetitive cognitive activity or sensations associated with pain among the least effective.

More recently, other researchers have also demonstrated the effectiveness of cognitive-behavioral skills training with TMD patients. In one such study, Flor and Birbaumer (1993) compared the efficacy of EMG

biofeedback, cognitive-behavioral therapy (CBT), and conservative medical treatment in chronic back pain patients and chronic TMD patients. The biofeedback and CBT consisted of eight sessions which lasted 60 min each. At posttreatment, all three groups showed improvement, with the biofeedback group exhibiting the most change. However, only the biofeedback group maintained significant decreases in pain severity, interference caused by pain, affective distress, and number of pain-related doctor visits at a 6- and a 24-month follow-up. Active coping scores were increased in the biofeedback and CBT groups, at both 6 and 24 months following treatment.

Dworkin *et al.* (1994) conducted a study to determine whether a minimal cognitive-behavioral intervention introduced prior to conventional TMD treatment would enhance the effects of conservative dental treatment alone. In addition, these authors hypothesized that patients classified as high in somatization and psychosocial dysfunction would not respond as favorably to this minimal intervention as those classified as low in somatization and psychosocial dysfunction. The cognitive-behavioral intervention was given in a group format of two to seven people and consisted of two sessions that were 2 hr each, spaced 1 week apart. Although no differences were found between the cognitive-behavioral group and the usual dental treatment group at a 3-month follow-up, the cognitive-behavioral group showed continued improvement in characteristic pain and pain interference during the 3- to-12-month follow-up interval, while the usual treatment group did not. As hypothesized, those classified as high in somatization and psychosocial dysfunction did not appear to benefit from the cognitive-behavioral intervention.

Although, as reviewed above, there have been many studies that have examined treatment outcomes on TMD and TMD-related disorders, most have major shortcomings in experimental design and documentation of outcome. The present study is unique in many ways. First of all, in the past, no one investigation evaluated the comparative effectiveness of the three treatments employed in the present investigation—biofeedback, cognitive-behavioral skills training, and *combined* biofeedback/cognitive-behavioral skills training. One would predict that a combined treatment program would produce more robust results than individually administered components because it would be best suited to most comprehensively addressing all the biopsychosocial aspects of TMD. Moreover, it is difficult to compare past studies in this area, as there was no consensus for the diagnostic criteria that comprise TMD. Invalid, nonstandardized schemas may have been used to assess and classify the patients. Consequently, what is thought to be the same population may in fact be heterogeneous. Further complicating the diagnostic issue is the inconsistent terminology used. Where one study examined only TMD patients, another may have included related disorders such as trigeminal neuralgia. This makes integrating findings questionable at best.

A major strength of the present study is the use of the now widely accepted RDC for the standardized diagnosis of TMD patients.

There are many other factors also contributing to the difficulty of cross-study comparisons. One factor is the number of treatment sessions the participants received. Studies varied significantly on the number of treatment sessions given, and some studies failed to indicate how many were included. Other common weaknesses include lack of control groups, lack of specification of symptom duration, and lack of objective dependent measures. In addition, case studies and studies with small sample sizes were frequently examined.

With these above methodological shortcomings in mind, the current study was carefully designed and novel in examining the relative effectiveness of four treatment methods on a sample of chronic TMD patients (i.e., patients seeking treatment and who had TMD symptoms for at least 6 months). The standardized RDC was used for the diagnosis of TMD. This was also a novel aspect of the present TMD treatment study. The treatment methods included cognitive-behavioral skills training, biofeedback, combined treatment, and a no-treatment condition. It was hypothesized that there would be a significant difference in Graded Chronic Pain Status (GCPS) and Characteristic Pain Intensity (CPI) scores (both of which are derived from the RDC) pretreatment to posttreatment for individuals receiving the three types of treatment, with no significant difference for those in the no-treatment condition. Relatedly, those receiving treatment would demonstrate significant improvements in mood, as assessed by the Profile of Mood States (POMS). This expected mood change is congruent with a biopsychosocial perspective of an interactive and reciprocal nature of pain and psychosocial functioning (Dworkin *et al.*, 1990; Turk, 1997).

METHODS

Subjects

Ninety-four chronic TMD patients (having TMD symptoms for at least 6 months) participated in this study. This sample size was determined on the basis of work by Cohen (1988), who has presented reasonable choices of "small," "medium," and "large" effects. For a 4×2 chi-square analysis, given a total of 94 subjects, there will be adequate power to detect both medium and large effects. Patients were referred by dentists and oral surgeons in the Dallas–Fort Worth area to participate in this ongoing study.[3] Participants

[3]The authors would like to thank the following dentists for referring patients for participation in this study: Drs. Stacy Cole, Edward Ellis, Rick Harper, Charles Holt, William Langston, James Moore, Richard Riggs, Douglas Sinn, Keith Thornton, and Gill Triplett.

were also recruited using flyers that were posted on college and university campuses and by advertisements placed in various Dallas area newspapers. Inclusion criteria consisted of males and females 18–65 years of age, of various ethnicities and educational levels. Patients must have endorsed past or present jaw or facial pain, clicking, popping, or locking of the jaw or have received a past diagnosis of TMD. Exclusion criteria consisted of individuals with a significant physical health condition (e.g., cancer, multiple sclerosis, carpal tunnel syndrome, fibromyalgia); individuals with six or more DSM-IV Axis I diagnoses, psychosis, or active suicidal ideation; and individuals who did not score above 15 on the CPI and, thus, were considered as "doing well" and not in need of treatment. Each participant was paid $20 for participation in the initial assessment. An additional $20 was paid for completing the end-of-treatment assessment to those individuals assigned to the no-treatment group.

Materials

Informed Consent Form. Consent for participation in the study was obtained from each participant prior to the initial evaluation.

General Information Questionnaire. Participants completed a general information questionnaire which asked about demographic information, general health, medications, the date the patient first experienced jaw pain, the date the person first sought treatment for jaw pain, the date of diagnosis of TMD, and current and previous treatment for TMD.

History Questionnaire, Forms 1 and 2. This questionnaire was developed by Widmer *et al.* (1992) and consists of 31 items. Items contain questions specific to TMD, such as location, intensity, and duration of pain; intraoral habits; questions relating to limitations of functioning, depression, and nonspecific physical limitations; and demographic questions. On Form 1, patients answer questions relating to their pain in the past 6 months, while on Form 2 they describe their pain in the past 3 months.

TMD Examination Form. Widmer *et al.* (1992) also developed this form. In the present study, this form was completed by examiners who were trained by an oral surgeon with extensive experience in the treatment of TMD. This training ensured correct location of palpation and completion of the TMD Examination Form, as the oral surgeon observed each rater reliably conduct a physical exam after training. "Recalibration" sessions with the oral surgeon were regularly held during the study to ensure continued 100% interrater reliability. Examiners recorded the following (pertaining to the patient): location of self-reported pain, opening pattern, measurements of vertical range of motion, presence and measurements of joint sounds upon opening and closing, measurements of excursions and protrusion, location

of reported pain upon excursions and protrusion, presence of joint sounds upon excursions and protrusions, and severity level of extraoral and intraoral muscle pain and joint pain with palpation.

The research diagnostic criteria (RDC) for TMD was edited by Dworkin and LeResche (1992) and was used to score the History Questionnaire and TMD Examination Form. As noted earlier, the RDC reveals whether there is presence of muscle disorders, disc displacements for each disc, and other joint conditions for each side of the jaw. The RDC also includes a rule-out of systemic arthritic disease and acute traumatic injury. In addition, the RDC is used to derive the Characteristic Pain Intensity (CPI) score and the Graded Chronic Pain Score (GCPS). The CPI is a score from 0 to 100 which measures severity of pain, with 100 being the most pain. The CPI is obtained by taking the mean score of questions 7 through 9 of the History Questionnaire (pain right now, worst pain, average pain), multiplied by 10. The History Questionnaire Form 1 is used at the initial evaluation and "the past 6 months" is the time of reference. The History Questionnaire Form 2 is completed posttreatment, and "the past 3 months" is the time of reference. GCPS is a score from 0 to 4 and is calculated from CPI score, change in activities due to pain, and number of disability days. Number of disability days added with a disability score comprise disability points, which is a factor used in computing GCPS. The disability score is a score from 0 to 100 derived from the mean of History Questionnaire questions 11–13, multiplied by 10. Questions 11–13 assess for the degree that pain has interfered with the patient's daily, social, and work activities. Functional TMD patients are defined as Grades I and II on the GCPS, which is indicative of no significant disability due to TMD. Dysfunctional chronic pain is defined as Grades III and IV on the GCPS.

Profile of Mood States (POMS). This is an adjective checklist that was developed by McNair and colleagues (1981). On a 5-point scale, participants rate 65 adjectives that describe subjective mood "during the past week including today" (Peterson and Headen, 1984). This checklist derives six factors: tension–anxiety, depression–dejection, anger–hostility, vigor–activity, fatigue–inertia, and confusion–bewilderment. A total mood disturbance score is also calculated by adding the raw scores for each factor except vigor, and then subtracting vigor from this total. The POMS was used as a self-report measure that assessed affective states at the beginning and end of treatment (Sessions 1 and 12).

Although the development of the POMS was aimed toward psychiatric outpatients, use with normal subjects has been endorsed by its authors and has been found to be a valid measure of mood states (Eichman, 1978; Peterson and Headen, 1984; Weckowicz, 1978). Internal consistency measures for the POMS are .84 and .95 for groups of 350 and 650 psychiatric

patients, respectively, as indicated by Kuder–Richardson formulas (Eichman, 1978).

Procedure

Initial Assessment. Informed consent was obtained after participants were explained the details of the study. They then filled out a payment voucher, the General Information Questionnaire, and the History Questionnaire Form 1. A dental examination, guided by the TMD Examination Form, followed the completion of these forms. During the initial assessment, participants were not informed about any opportunity for receiving treatment.

Group Assignment. Chronic patients (participants who first sought treatment for TMD 6 months or more before the initial assessment) were assigned to a group immediately following the initial assignment. Those participants who were not chronic were considered "acute" patients. These participants were followed at 3 and 6 months after the initial assessment, after which time they were considered "chronic" and could be assigned to a group. Patients were assigned to a group in a semirandom fashion, using the urn method of random assignment (Lachin *et al.*, 1988; Stout *et al.*, 1994; Wei and Lachin, 1988), to keep demographic variables and type of chronic TMD comparable across groups. The groups were biofeedback, cognitive-behavioral skills training (CBST), combination biofeedback/CBST (combined treatment), and no-treatment control (no treatment).

Treatment. Each treatment consisted of 12 sessions which lasted an average of 1.5 hr each, except for the combined treatment group, which lasted 2 hr. Treatment sessions were held twice a week for the first 4 weeks and once a week for the remaining 4 weeks. Treatment was administered in a standardized fashion using a standard treatment protocol manual. Patients received workbooks which included reading assignments and homework exercises to be completed outside of sessions. Missed or extra sessions were documented. Missed sessions were made up before the next session in the sequence administered. Participants who prematurely dropped out of treatment were excluded from the analyses. Treatment credibility was ensured by obtaining a rating of overall acceptance of treatment goals by the participants. Acceptance of treatment goals was rated on a 1- to 10-point scale, with 10 being the highest possible score. The median scores were 10, 9, and 9 for the CBST, biofeedback, and combined treatment groups, respectively. Treatment compliance was ensured by obtaining a rating of attendance to sessions and homework completion. This was rated on a 20-point scale by the therapists, with 20 being the highest possible score. The median scores

were 18, 17.5, and 16.5 for the CBST, biofeedback, and combined treatment groups, respectively. Treatment was conducted by clinical psychologists and advanced doctoral students in a clinical psychology program. All therapists received individual and group training and weekly supervision by a licensed psychologist, who was a senior member of the study team. All treatment sessions were audiotaped, and these audiotapes were randomly reviewed to ensure consistency of content, with examiners rating various domains of therapist competency using a therapist competency rating form. The domains of inquiry for therapist competency included treatment process and therapist characteristics. Technical competence of the therapist in handling and using the equipment, and utilization of feedback information were also rated for the biofeedback and combined treatment. All therapists met criteria for competency when the tapes were regularly reviewed.

Development of Treatment Protocols. The basic CBST treatment protocol and the skills training portion of the combination treatment protocol came from a modified adaptation of the Lewinsohn *et al.* (1984) cognitive-behavioral treatment program for depression. In addition, features of other pain management programs were integrated into it. Topics in the current study's treatment protocol included a rationale for skills training, designing a self-change plan, relaxation training, controlling pain through distraction techniques, pleasant activity scheduling, formulating a pleasant activities plan, cognitive restructuring, self-instructional training, social skills training including assertiveness training, maintenance of skills, and development of a life plan. The patient workbook for this treatment protocol was adapted from exercises by Lewinsohn *et al.* (1986), as well as various pain management programs. It should be noted that, to make this treatment protocol salient for TMD patients, we introduced the concept of stress in presenting the rationale for the treatment. Most laypersons are now familiar with the term stress and how it affects everyday living. Patients were informed that persistent medical and dental problems are associated with stress, which can lead to significant emotional reactions such as anxiety and depression. Throughout the treatment protocol, the term stress was used so that all patients assumed that the protocol was a general treatment program for stress-related problems.

The biofeedback treatment protocol followed a format developed by the second author (who specializes in biofeedback and stress management techniques) in his past and current treatment of TMD patients. This treatment format was also patterned after that used by Alan Glaros, Ph.D. (personal communication) in his treatment of TMD patients. A J&J (Poulsbo, WA) Model M-57 EMG Biofeedback Unit and a J&J Model T-68 Temperature Biofeedback Unit were used for the biofeedback treatment protocol, as well as the biofeedback portion of the combined treatment protocol. This treatment protocol also included relaxation training. Fifteen minutes of

temperature biofeedback and 15 min of EMG biofeedback were included.[4] The electrodes were placed over the frontales muscles.

The combined CBST and biofeedback treatment included components of both of the above protocols. Of course, even though there were overlapping sessions (e.g., relaxation training, social learning conceptualizations, and maintaining social skills), this required that sessions for this treatment condition be somewhat longer in length (an average of 2 hr rather than 1.5 hr). In many treatment evaluation studies, the issue of whether to keep length of session comparable across treatment sessions, or to shorten the combined treatment, is often raised. We took the position that it was important to maximize treatment impact even if a treatment requires somewhat more time than another. The time period over which the treatment were administered, however, was kept constant.

Finally, it should be noted that a placebo-control condition was not included in this study because of problems associated with such a condition. O'Leary and Borkovec (1978, p. 823) have discussed such problems and pointed out that using a placebo control group in therapy research may be "theoretically, methodologically, practically, and ethically unsound." They appropriately state that theoretical and methodological problems in developing placebo groups include difficulties developing an inert psychological treatment, the unlikelihood of a therapist being able to accept or have any confidence in implementing a placebo condition for more than one or two sessions, and the probability that patients would drop out of a placebo group over time. Ethical considerations include the following: placebos are inherently deceptive, and they deter the patient from seeking active treatment during the course of the experimental evaluation; when patients discover that they were given a placebo, they may feel angered that time was wasted at their expense; and, finally, subjects given a placebo will not improve and some may deteriorate resulting in harm to the subject. For these valid concerns, a placebo group was not included in this study. All patients, though, were compared to a standard nonsurgical dental care-only group (e.g., treatment involving splints, medication, physical therapy, etc.) that controlled for therapeutic contact and expectancy in terms of going through comprehensive biopsychosocial evaluations and questioned about any therapeutic improvements.

End-of-Treatment Assessment. Upon completion of the treatment sessions, participants in the treatment conditions filled out the History Questionnaire Form 2 and the POMS. They were also dentally examined using the RDC format. Participants in the no-treatment condition were assessed

[4]The authors would like to thank Alan Glaros, Ph.D., for his help in developing the biofeedback protocol for TMD patients employed in this study.

Table I. Demographic Variables of the Study Population

	CBST	Biofeedback	Combined treatment	No treatment	Total
Number of subjects	22	23	24	25	94
Female	18	18	21	20	77
Male	4	5	3	5	17
Mean age	35.55	38.13	34.21	35.24	35.76
(SD)	9.14	(10.95)	(8.26)	(11.16)	(9.92)
Mean years of education	15.91	15.74	15.92	14.68	15.54
(SD)	1.82	(2.24)	(1.91)	(2.19)	(2.09)
Ethnicity					
Caucasian	18	19	19	18	74
African-American	2	0	2	4	8
Hispanic	1	3	3	3	10
Other	1	1	0	0	2
Duration of TMD pain (months)	102.68	70.27	81.25	81.16	83.70
(SD)	(113.32)	(50.05)	(78.92)	(83.74)	(83.80)

3 months after their assignment to the no-treatment control group to assess them at approximately the same time as those receiving treatment. They received $20 for their participation.

RESULTS

Demographic factors of the study sample are represented in Table I. As can be seen, the mean age of participants was 35.76, and 82% of the participants were female. The mean number of years of education was 15.54. Seventy-nine percent of the study population were Caucasian, 8% were African-American, 11% were Hispanic, and 2% were of other ethnic backgrounds. One-way analyses of variance (ANOVAs) and chi-square analyses were conducted to compare these variables across the four groups in order to determine any significant differences among groups. Groups were not significantly different on age [$F(3,90) = .653$, $p = .583$], education [$F(3,90) = 2.040$, $p = .114$], level of chronicity [$F(3,89) = .571$, $p = .636$], gender [$\chi^2(3) = .775$, $p = .856$], or ethnicity [$\chi^2(9) = 7.024$, $p = .635$].

A chi-square test of independence was also computed to compare pretreatment GCPS to determine if a significant difference existed among the four groups on this variable; groups were not significantly different. Also, a one-way ANOVA, computed to compare pretreatment CPI among the four groups, revealed no significant differences among groups.

Table II presents the percentages of treatment responders in each of the four groups. Michael Von Korff (personal communication, July 28, 1994), who

Table II. Percentages of Treatment Responders

	CPI responders[a]	GCPS responders[b]
CBST	31.8%	63.6%
Biofeedback	52.2%	60.9%
Combined	37.5%	70.8%
No treatment	28.0%	56.0%

[a] Defined as patients who decreases at least 33% from pretreatment to posttreatment CPI score.
[b] Defined as patients who receive a posttreatment GCPS of 0 or 1 or participants whose GCPS score decreases from pretreatment to posttreatment.

helped develop the CPI and GCPS measures included in the RDC, suggested that a patient be considered a "CPI responder" if he/she has at least a 33% decrease from pretreatment CPI score to posttreatment CPI score. Additionally, Von Korff suggested that a "GCPS responder" be defined as a patient with a posttreatment GCPS of 0 or 1. Dworkin *et al.* (1994) also contend that those receiving a GCPS score of 0 or 1 significantly differ on pain-related disability. In addition, it has been suggested that those with a decrease from pretreatment GCPS to posttreatment GCPS be considered responders. Finally, a "POMS responder" was defined as a patient with a decrease in total mood disturbance score from pretreatment to posttreatment on the POMS.

CPI. A repeated-measures ANOVA showed that there were significant decreases in CPI scores from pretreatment to posttreatment among all treatment conditions [$F(1,90) = 50.598$, $p = .000$]. In addition, a significant Time × Group interaction was found for CPI score [$F(3,90) = 2.844$, $p = .042$]. This indicates that there was a significant change in reported pain from pre- to posttreatment based on the type of treatment received. The ANOVA was followed by a planned contrast test which compared the three treatment conditions combined versus the no-treatment control group. A significant difference was found between the three treatment groups combined and the no-treatment group [$t(90) = 2.530$, $p = .013$]. This indicates that treatment was better than no treatment. The specific means are presented in Table III.

Table III. Pretreatment and Posttreatment CPI Means

		Pre CPI		Post CPI		Analysis	
	N	Mean	SD	Mean	SD	*F*	*p*
CBST	22	54.09	15.49	41.51	16.83	13.595	.001
Biofeedback	23	60.00	18.26	40.00	22.25	23.903	.001
Combined	24	57.15	14.54	42.50	15.11	16.783	.001
No treatment	25	47.73	17.48	42.53	23.56	2.093	.161

To compare each treatment to the no-treatment group, Dunnet planned-comparison *t* tests were also conducted, and they revealed a significant difference between the biofeedback treatment group and the no-treatment control group ($p = .014$), indicating that biofeedback significantly decreased pain severity scores compared to no treatment. The Dunnet test also indicated that there were no differences between each of the other treatment comparisons.

Four within-group ANOVAs were also performed to compare pretreatment to posttreatment CPI scores. Significant within-group effects were found for the cognitive treatment group [$F(1,21) = 13.595$, $p = .001$], the biofeedback treatment group [$F(1,22) = 23.903$, $p = .001$], and the combined treatment group [$F(1,23) = 10.180$, $p = .004$]. There was no significant difference between pretreatment and posttreatment CPI score for the no-treatment control group.

GCPS. A chi-square analysis was computed to determine whether a significant difference existed in pretreatment to posttreatment GCPS score among the four treatment conditions. Results revealed no significant difference in pretreatment to posttreatment GCPS score among the four groups.

POMS. To provide a test for the overall change in the six POMS variables, a Time (pretreatment and posttreatment) × Treatment Group (CBST, biofeedback, and combined) MANOVA was conducted. A significant multivariate effect for Time was found [Hotellings $T^2 = 1.20$, approximate $F(5,59) = 14.10$, $p < .001$], indicating a general change in mood state from pretreatment to posttreatment for all treatment groups. There was no significant Treatment Group effect. To explore the specific changes, a series of repeated measures ANOVAs was then conducted. Analyses revealed that there were significant improvements on all six POMS variables, as well as on the Total Mood Disturbance variable, from Session 1 to Session 12 among all three treatment conditions ($p < .001$). Table IV presents the results of these analyses. Table V presents the means and standard deviations of the changes for each POMS measurement from pre- to posttreatment.

DISCUSSION

Results of this present study clearly demonstrated that the CPI score significantly decreased, from pretreatment to posttreatment, for the three treatment groups, indicating a decrease in self-reported pain. The three treatment groups combined demonstrated significantly greater change than the no-treatment control group, with additional analysis of the CPI variable revealing no significant differences among the three treatment conditions. Moreover, a significant pretreatment to posttreatment group effect was found, with the biofeedback group displaying significantly greater reductions relative to the no-treatment control group. Also, significant differences in pre- to

Table IV. Repeated-Measures ANOVAs of All Factors on the POMS ($n = 66$)

	F	p
Tension Change	36.887	.000
Group	.285	.753
Tension Change × Group	1.845	.166
Depression Change	15.312	.000
Group	.086	.917
Depression Change × Group	.171	.843
Anger Change	11.517	.001
Group	.362	.698
Anger Change × Group	.096	.909
Vigor Change	31.968	.000
Group	.037	.964
Vigor Change × Group	.134	.875
Fatigue Change	30.297	.000
Group	.154	.858
Fatigue Change × Group	1.715	.188
Confusion Change	23.430	.000
Group	.177	.838
Confusion Change × Group	.494	.612
Total Mood Disturbance Change	49.430	.000
Group	.016	.984
Total Mood Disturbance Change × Group	.717	.492

posttreatment CPI scores were found for the three treatment conditions but not for the no-treatment condition. Although analyses of the GCPS variable yielded no significant differences among the four treatment groups, this may have been due to the categorical nature of this measure. There were only five levels available (0–IV) to note any change, which would have to have been dramatic (especially if starting out at the highest dysfunctional level at pretreatment).

Table V. Means and Standard Deviations (SD) of the Change of Each POMS Measure from Pre- to Posttreatment

	CBST		Biofeedback		Combined	
	Mean	SD	Mean	SD	Mean	SD
Tension	−3.4	8.5	−7.6	8.3	−7.4	8.2
Depression	−2.9	10.0	−4.1	6.4	−3.9	5.8
Anger	−3.1	6.2	−3.5	8.0	−4.2	10.4
Vigor	−5.5	11.4	−6.9	8.9	−6.5	6.6
Fatigue	−3.5	8.3	−7.0	8.6	−8.6	10.7
Confusion	−3.7	8.0	−5.9	7.5	−4.2	7.5
Total Mood Disturbance	−17.2	25.5	−25.1	26.7	−25.9	26.3

The CPI results of this study, though, clearly demonstrate that all three treatments are effective in reducing the pain that TMD patients experience. Although the biofeedback treatment was the most effective at reducing pain in TMD patients, the cognitive-behavioral skills training and the combined treatment approaches were also more therapeutically effective than the no-treatment control condition. Finally, all three treatment groups displayed a significant improvement in positive mood states, as assessed by the POMS, from pretreatment to posttreatment. As noted earlier, these findings are congruent with the biopsychosocial perspective of an interactive and reciprocal nature of pain and psychosocial functioning (Dworkin *et al.*, 1990; Turk, 1997).

The etiology of TMD may be directly related to the hyperactivity of muscles of mastication (Carlsson and Gale, 1977; Carlsson *et al.*, 1975; Dahlstrom *et al.*, 1982; Dohrmann and Laskin, 1978; Gessel, 1975; Kight *et al.*, 1999). It is not then surprising that biofeedback was the most effective treatment at reducing pain, since it focuses directly on reducing EMG activity levels. These results also concur with those reported by Flor and Birbaumer (1993), who found that patients administered biofeedback showed more improvement at posttreatment compared to patients who received cognitive-behavioral therapy or conservative medical treatment. Relatedly, at first glance, it may seem puzzling that the combined treatment group did not have greater effects than the biofeedback group had on reducing pain, since this group also received biofeedback in their treatment. A possible explanation is that, because they were receiving cognitive-behavioral skills training and biofeedback in each session, this may have affected the patients' perception of the problem. Most TMD patients view their pain as a physically based, rather than a psychologically based, problem. Thus, it is understandable that they might be more motivated to fully engage in biofeedback treatment, which focuses on physiology, versus a combined treatment, which includes a psychological component.

The same reasoning can be used to explain why those in the cognitive-behavioral treatment group did not do as well as those in the biofeedback treatment group. Cognitive-behavioral skills training is a strictly psychological treatment which focuses on psychological difficulties not necessarily related to TMD. Thus, although the skills learned by those in the cognitive-behavioral treatment group helped reduce their TMD pain, it seems logical that a treatment focused on physiology would be more effective, especially if TMD is indeed caused by the hyperactivity of muscles.

The results of this study suggest that biofeedback is the most effective of the three treatment conditions in pain reduction, and there are definite advantages to this. First, it is the easiest of the three treatments to administer to patients. In addition, it is more time efficient than either cognitive-behavioral skills training or a combined treatment. However, a minor drawback also

exists. Biofeedback is more costly than cognitive-behavioral skills training in that the proper equipment and supplies are needed.

It was also hypothesized that participants in all three treatment conditions would show significant improvements on all factors measured by the POMS. This was indeed the case, as there were significant decreases in the anger/hostility, confusion/bewilderment, depression/dejection, fatigue/inertia, and tension/anxiety scores from Session 1 to Session 12. Vigor/activity scores significantly increased among those in all three treatment conditions. In addition, there was a significant decrease in the total mood disturbance score for all treatment groups, which takes into account the other six factors measured. There were no significant differences among the three treatment conditions on any of these factors. Thus, consistent with the biopsychosocial perspective, improved mood and reduction of pain seem to be interactive. These factors likely influence one another, with improved mood contributing to decreased pain and decreased pain contributing to improved mood. Pain severity and level of mood disturbance were clearly not the only factors influencing one another, as demonstrated by the lack of significant differences in affective state scores between those in the biofeedback group and those receiving other treatments.

It should be noted that 82% of the study population was female. What implications does this have in terms of generalizability of the results? Although in the general population, no differences in the prevalence rate of TMD are seen between genders (Duckro *et al.*, 1990; Helkimo, 1979), the ratio is at least 3:1 of females to males in patient samples (Reider *et al.*, 1983). Since a large majority of those who seek treatment are females, the results of this study are generalizable to the majority of those who actually seek treatment. Different ethnic backgrounds were not representative of the general population, with 79% being Caucasian, 8% African-American, 11% Hispanic, and 2% of other ethnic backgrounds. Penn *et al.* (1995) indicate that minorities do not seek physician care as readily as Caucasians. Thus, the current findings are probably reflective of differences among ethnicities in health care-seeking behavior. Although patients were recruited from many sources, the mean number of years of education was 15.54, which is considerably more than that of the general population. It would be useful for future studies to include a higher percentage of males, and a greater range of education levels, to determine if results are similar.

In conclusion, the primary objective of this study was to determine the relative efficacy of cognitive-behavioral skills training, biofeedback, and a combined treatment approach to TMD. This was the first investigation to make this comparative evaluation, while simultaneously using the standardized RDC for TMD diagnoses. Results of this investigation demonstrate that biofeedback was the most effective treatment approach according to CPI

responder and GCPS responder measures. However, cognitive-behavioral skills training and a combined treatment were also effective at reducing pain and pain-related disability, relative to the no-treatment condition. Moreover, all three treatment conditions produced significant improvement in positive mood states, as assessed by the POMS. Thus, any of the three treatments is better than none. A 1-year follow-up is presently being conducted on these patients, and this will evaluate the long-term effectiveness of the treatment methods for patients with chronic TMD.

ACKNOWLEDGMENT

This research was supported by Grants ROI DE10713 and K02 MH01107 awarded to Dr. Gatchel from the National Institutes of Health.

REFERENCES

Carlsson, S. G., and Gale, E. N. (1977). Biofeedback in the treatment of long-term temporomandibular joint pain. *Biofeed. Self-Regul.* 2: 161–171.

Carlsson, S. G., Gale, E. N., and Ohman, A. (1975). Treatment of temporomandibular joint syndrome with biofeedback training. *J. Am. Dent. Assoc.* 91: 602–605.

Cohen, J. (1988). *Statistical Power Analyses for the Behavioral Sciences*, Hive and Landen, Hillsdale, NJ.

Dahlstrom, L., Carlsson, G. E., and Carlsson, S. G. (1982). Comparison of effects of electromyographic biofeedback and occlusal splint therapy on mandibular dysfunction. *Scand. J. Dent. Res.* 90: 151–156.

Dohrmann, R. J., and Laskin, D. M. (1978). An evaluation of electromyographic biofeedback in the treatment of myofascial pain dysfunction syndrome. *J. Am. Dent. Assoc.* 96: 656–662.

Duckro, P. N., Tait, R. C., Margolis, R. B., and Deshields, T. L. (1990). Prevalence of temporomandibular symptoms in a large United States metropolitan area. *J. Craniomandib. Pract.* 8: 131–138.

Dworkin, S. F. (1994). Temporomandibular disorders and chronic pain: Disease or illness? *J. Prosthet. Dent.* 72: 29–38.

Dworkin, S. F., and LeResche, L. (1992). Research diagnostic criteria for temporomandibular disorders. *J. Craniomandib. Disord. Fac. Oral Pain* 6: 301–355.

Dworkin, S. F., Von Korff, M. R., and LeResche, L. (1990). Multiple pains and psychiatric disturbance: An epidemiologic investigation. *Arch. Gen. Psychiatry* 47: 239–244.

Eichman, W. J. (1978). The Profile of Mood States. In Buros, O. K. (ed.), *The Eighth Mental Measurements Yearbook*, Gryphon, Highland Park, NJ, pp. 1016–1018.

Fernandez, E., and Turk, D. C. (1989). The utility of cognitive coping strategies for altering pain perception: A meta-analysis. *Pain* 38: 123–135.

Flor, H., and Birbaumer, N. (1993). Comparison of the efficacy of electromyographic biofeedback, cognitive-behavioral therapy, and conservative medical interventions in the treatment of chronic musculoskeletal pain. *J. Consult. Clin. Psychol.* 61: 653–658.

Gessel, A. H. (1975). Electromyographic biofeedback and tricyclic antidepressants in myofascial pain-dysfunction: Psychological predictors of outcome. *J. Am. Dent. Assoc.* 91: 1048–1052.

Glaros, A. G., and Glass, E. G. (1993). Temporomandibular disorders. In Gatchel, R. J., and Blanchard, E. B. (eds.), *Psychophysiological disorders*, American Psychological Association, Washington, DC.

Helkimo, M. (1979). Epidemiological surveys of dysfunction of the masticatory system. In Zarb, G. A., and Carlsson, G. E. (eds.), *Temporomandibular Joint Function and Dysfunction*, Munksgaard, Copenhagen, pp. 175–201.

Kight, M., Gatchel, R. J., and Wesley, L. (1999). Temporomandibular disorders: An example of the interface between psychological and physical diagnoses. *Health Psychol.* 18: 177–182.

Lachin, J. M., Matts, J. P., and Wei, L. J. (1988). Randomization in clinical trials: Conclusions and recommendations. *Control. Clin. Trials* 9(4): 365–374.

Lewinsohn, P. M., Antonuccio, D. O., Breckenridge, J. S., and Teri, L. (1984). *The Coping with Depression Course: A psychoeducational Intervention for Unipolar Depression*, Castalia, Eugene, OR.

Lewinsohn, P. M., Munoz, R. F., Youngren, M. A., and Zeiss, A. M. (1986). *Control Your Depression*, Simon & Schuster, New York.

McNair, D. M., Lorr, M., and Dropelman, L. F. (1981). *Profile of Mood States*, Educational and Testing Service, San Diego, CA.

O'Leary, K. D., and Borkovec, T. D. (1978). Conceptual, methodological, and ethical problems of placebo groups in psychotherapy research. *Am. Psychol.* 56: 821–830.

Penn, N. E., Kar, S., Kramer, J., Skinner, J., and Zambrana, R. E. (1995). Panel VI: Ethnic minorities, health care systems, and behavior. *Health Psychol.* 14(7): 641–646.

Peterson, R. A., and Headen, S. W. (1984). Profile of Mood States. In Keyser, D. J., and Sweetland, R. C. (eds.), *Test Critiques, 1*, Test Corporation of America, Kansas City, pp. 522–529.

Reider, C. E., Martinoff, J. T., and Wilcox, S. A. (1983). The prevalence of mandibular dysfunction. Part I: Sex and age distribution of related signs and symptoms. *J. Prosthet. Dent.* 50: 81–88.

Stout, R. L., Wirtz, P. W., Carbonari, J. P., and Del Boca, F. K. (1994). Ensuring balanced distribution of prognostic factors in treatment outcome research. *J. Stud. Alcohol* 12(Suppl.): 70–75.

Turk, D. C. (1997). Psychosocial and behavioral assessment of patients with temporomandibular disorders: Diagnostic and treatment implications. *Oral Surg. Oral Med. Oral Pathol.* 83: 65–71.

Weckowicz, T. E. (1978). Profile of Mood States. In Buros, O. K. (ed.), *The Eighth Mental Measurements Yearbook*, Gryphon, Highland Park, NJ, pp. 1018–1019.

Wei, L. J., and Lachin, J. M. (1988). Properties of the urn randomization in clinical trials. *Control. Clin. Trials* 9(4): 345–364.

Widmer, C. G., Huggins, K. H., and Friction, J. (1992). Research diagnostic criteria for temporomandibular disorders: Review, criteria, examinations and specifications, critique. Part III: Examinations and history data collection. *J. Craniomandib. Disord. Facial Oral Pain* 6(4): 335–355.